Ecological Aquaculture to 2050

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Reference: Costa-Pierce, B.A. 2015. Ecological Aquaculture to 2050. Chapter 18 in *Ecological Aquaculture: Principles and Practices for the Blue Revolution to 2050*.
http://ecologicalaquaculture.org

The Blue Revolution Needs an Alternative Path

FAO (2014) estimate that 77% of all global fish stocks are either fully exploited with no room for further expansion; or are overexploited, depleted, or recovering from depletion owing to excess fishing pressure. FAO (2014) project that capture fisheries production from 2004 to 2030 will remain stable at 86-87 million metric tons (MMT), while aquaculture will almost double from 45 to 83 MMT during the same time. The World Bank (2013) predicts by 2030 aquaculture will provide nearly two-thirds of the global fish consumption, compared to the 51% it currently represents.

In my opinion, aquaculture's future growth as projected by FAO and the World Bank will not occur unless aquaculture industries and policy-makers choose an alternative path one divergent from the failed "green" revolution that proceed it with its adverse environmental, ecological, community, social, and ethical impacts.

The Green Revolution raised agricultural yields, especially in India, but did not strive to involve agribusiness and multinational food corporations with communities, farmers, or local governments to build, invest in, and nurture change in local institutions, communities and cultures. As a result, accelerated production did not alleviate poverty or eliminate hunger, and production gains damaged the environment. Numerous multidisciplinary studies, especially in Mexico and India, have shown that the Green Revolution's expensive seed, fertilizer, pesticide and irrigation "packages" favored a minority of economically-privileged farmers (Rosset et al., 2006). Environmentally, the green revolution produced a well-documented litany of "externalities": accelerated pollution of rivers and water tables, widespread soil degradation, losses of biodiversity, and occupational pesticide poisonings. In India, the Green Revolution's "technology packages" required irrigation; so the government subsidized the digging of tens of thousands of wells which pumped many water tables dry, forcing vast areas to return to traditional, dryland farming systems. Most of India's grains were exported, so national elites profited mightily. The local, hydrological result of the Green Revolution's technology packages was "the sacrifice of India's ancient aquifers to the international grain trade" (Rosset et al., 2006).

Modern aquaculture is biotechnologically complex, and, so are societies (urban, rural, rich, poor, etc.). Communities can either embrace aquaculture, a dramatic change for many, and accommodate the necessary social transformations, or reject such changes and continue their social, cultural, and economic evolutions without aquaculture. One of the fundamental problems of modern industrial aquaculture development is the lack of understanding and

planning for the social/community transformations wrought by aquaculture innovations, the lack of knowledge on how to govern these aquaculture innovations, and the lack of planning for community access to locally grown products, which would yield additional social capital to aquaculture developers.

In my view, we have yet to take two crucial steps needed to develop the alternative path for aquaculture development as social transformation:

(1) Lack of industry commitment to implementation of an ecosystem approach to aquaculture (EAA);

(2) Development of alternative institutions that team government, universities' fisheries and marine science departments, and industry, whose mission would be to multidisciplinary learning, social transformation, and the aquaculture "innovation portfolio".

University involvement is essential as a "keeper of the flame" since neither government nor industry can effectively play the role of an honest broker. But universities are balkanized into many disparate marine science, fisheries, ecology, economics, business, and other areas of applied scholarship and service. Universities however can be a neutral convener and purveyor who can help lead the integration of an EAA with institutions committed to social change who pay close attention to market and societal transformations (such as progress towards: internationalization and multiculturalism, sustainability, bioregionalism, carbon footprints/trading/food miles). Societal transformations need time and stable funding bases to foster unique partnerships. Such type of leadership is fully underway in agriculture, where comprehensive planning for "agroecosystems" (Gliessman, 1998, 2006) occurs.

Why are we not planning for "aquaculture ecosystems" (Costa-Pierce, 2003)?

<u>An Ecosystem Approach to Aquaculture (Natural and Social Ecology)</u>

Implementing an ecosystem approach to aquaculture (EAA) is a major global trend (Soto and 22 co-authors, 2008. At an FAO Workshop on EAA in Mallorca, Spain in 2007, an EAA was defined as "a strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity, and resilience of interlinked social-ecological systems". Applying an ecosystem-based approach must involve physical, ecological and social systems in the planning for community development, while also taking into account stakeholders in the wider social, economic and environmental contexts of aquaculture. By applying such a comprehensive approach, it would be inadequate to review the "environmental impacts of aquaculture", but fail to examine fully the environmental benefits of aquaculture (Rensel and Forster, 2008), or to neglect the numerous opportunities for designing and engineering ecological aquaculture systems.

The wisdom of integration of aquaculture, agriculture and animal husbandry on small farms in Asia is that new, human-managed land-water ecosystems are created, that are definable as distinct aquaculture ecosystem typologies. These aquaculture ecosystems closely resemble natural ecosystems having their own structure and functions, closely-coupled nutrient recycling pathways, and ecological management strategies (De la Cruz et al., 1992; Dalsgaard & Oficial, 1997; Edwards, 2008, 2015). In these farming ecosystems, addition of aquaculture into the mix of farm enterprises can greatly increase the efficiencies of bioresource flows and profitability (Ruddle & Zhong, 1988; Lightfoot et al., 1993). Such integrated systems provide the following advantages:

- synergy, complementarity, adaptability: "polyvalent" technologies are "market-driven",
- drought-proofing: efficient use in agriculture of warm, fertile irrigation waters from aquaculture,
- waste-treatment capability: ponds are "sunlit rumens" (Schroeder, 1980) processing low quality agricultural by-products into high quality aquatic proteins, and
- restoration capability: conversion of marginal lands to prime agricultural lands by managing long-term cycles (up to 10 years) between agriculture and aquaculture systems.

I recommend the adoption of ecological aquaculture as the operating pedagogy for aquaculture development worldwide in order to:

- help define and refine the “Aquaculture Toolbox”, e.g. the use of aquaculture techniques to restored damaged aquatic ecosystems (Costa-Pierce and Bridger, 2002).
- get beyond endless user conflicts by creating stakeholder processes with meaning so that ecological aquaculture becomes the norm as an exciting, knowledge-based challenge that has the potential to revitalize and be a vital part of the future of working waterfronts, rather than a “blood sport”.
- use aquaculture for rural and urban community development. Use aquaculture tools, exercises and metaphors for increasing standards in schools to capture the imagination, show ingenuity and innovation. Use aquaculture to enhance multi-disciplinary environmental scholarship.
- move aquaculture into the mainstream of the emerging fields of restoration ecology, urban ecology, ecological engineering, and industrial ecology.

- bridge the gap quickly between water farming and harvesting. Marine fishers are diversifying from capture to mixed capture/culture; more traditional fishing/shellfishing families are adopting aquaculture. Pioneering connections between captures fishers and aquaculture farmers are developing, for example, the use of non-food grade fishery by-products (i.e. fishery by-catch and discards).

- better connect aquaculture technologies to markets and consumers. In the developed world, aquaculture products are discretionary products that can be rejected by the public, making the enterprise economically fragile.

- stabilize the regulatory environment. Future farmers are tired of an overlapping, incongruent, and oftentimes nonsensical, and certainly ever-changing regulatory environment. New agencies at all levels of society seem to want in. Much of the current lack of aquaculture development in the world, and especially in areas like the USA which are said by FAO (Kapetsky et. al., 2013) to have high potential for development, are plagued by the use of poor, outdated data to promote advocacy agendas.

Aquaculture has intimate connections not only with capture fisheries, environments, but also with agriculture, markets, and marine policy and regulatory bodies. Accelerated production of aquatic proteins cannot be evaluated in a vacuum separate from other types of land-based animal agriculture or ocean-based capture fisheries since these food systems use similar (and sometimes competing) inputs and outputs, face similar policy and regulatory environments, and have to deal with common consumers and decision-makers. More holistic planning perspectives are needed to ensure the survival of traditional coastal fishing and aquaculture communities and to link aquaculture science, industry, and society in order to design effective policies, practices and technologies to address the many challenges ahead.

But the blue revolution cannot be a modern clone of the "green revolution". What is required is a well-evaluated acceleration of multi-disciplinary, industry-relevant applied research, and regulatory transparency and stabilization that will lead to better policy-making for aquaculture's "real realities"; not perceived ones. The blue revolution will need to adopt fully international conventions such as FAO's Code of Conduct for Responsible Fisheries and the Ecosystems Approach to Aquaculture.

Ecological aquaculture is a process, an adaptive planning and management process that, over time, will open the space for the "evolution of the blue revolution" of ecologically integrated aquaculture systems that have positive impacts on both the natural and social welfare of coastal communities worldwide.

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